[redacted]

[redacted]

[redacted]

(1)

710/693

UNCLASSIFIED

AD-A954 965

WATERTOWN ARSENAL LABORATORY

MEMORANDUM REPORT

NO. WAL 710/693

DTIC ELECTE AUG 1 2 1985 S D

Resistance of Variously Chemically Balanced 18-8 Stainless Steels in Various Conditions of Hardness to Perforation by Flak-Simulating Projectiles

C

ATI - 39 247

[redacted]

Regraded ... by Auth ...
C. O. Watertown Arsenal
... AR
380-5, dtd 6 June 1952
13 May 1955 W. S. WOODS
date ... Laboratory
Sec Adm

BY

J. F. SULLIVAN
Asst. Engineer

This document has been approved for public release and sale; its distribution is unlimited.

[redacted]

Regraded Unclassified
by authority of C.O. Watertown
Arsenal.
26 May 1961 Paul O Mc Manus
date PAUL O. MC MANUS
Security Administrator

UNCLASSIFIED

APR 25 1945

DTIC FILE COPY

DATE 18 September 1944

WATERTOWN ARSENAL
WATERTOWN, MASS.

[redacted]

WATERTOWN ARSENAL LABORATORY

MEMORANDUM REPORT NO. WAL 710/693

Twenty-First Partial Report on Problem B-8.2 A-1

18 September 1944

Resistance of Variously Chemically Balanced 18-8 Stainless Steels in Various Conditions of Hardness to Perforation by Flak-Simulating Projectiles

1. As part of a general program of development of body armor component materials[1], tests have recently been conducted at this arsenal on three different chemically balanced 18-8 (type 302) stainless steels in 1/4 hard, 1/2 hard and full hard tempers.

2. Increasing the nickel content from 7% to 9.5% brought about an increase in yield strength and a decrease in elongation whereas the tensile strength remained substantially unaffected. These lower elongation values are reflected in a generally inferior resistance to perforation exhibited by the steels containing greater amounts of nickel. However, the resistance of even the best of these steels is considerably inferior to that of Hadfield manganese steel of equivalent weight.

3. Samples of 18-8 (type 302) stainless steel in three different alloys, each in three different conditions of hardness, were submitted by the Republic Steel Corporation. Hardness and thickness determinations were made at this arsenal and are included in Table I, which also sets out the results of the tests for resistance to perforation. Samples were clamped rigidly to wooden ballistic frames and impacted fairly in unsupported areas with cal. .45 steel-jacketed ball projectiles and with cal. .22 fragment-simulating projectiles, G-2[2]. Chemical analysis and physical properties, as determined in the laboratories of the supplier, appear in Table II, Figure 1 graphically represents the results of the firing tests as a function of Rockwell "C" hardness values.

---

1. O.O. 422.3/71(c) - Wtn 470.5/7443(c), dated 28 September 1943.

2. Watertown Arsenal Laboratory Memorandum Report No. WAL 762/253, "Development of a Projectile, to Be Used in Testing Body Armor, to Simulate Fragments of a 20 mm. H.E. Projectile" 7 January 1944.

4. Examination of the data in Table II discloses a decrease in elongation and an increase in yield strength accompanying an increase in nickel content while the tensile strength remains essentially unchanged. Thus the best combination of tensile strength and elongation is realized when the nickel content is lower. Consistent with past experience[3] the materials best combining these two characteristics are most resistant to flak-simulating projectile perforation. Therefore, the 7% nickel alloy affords highest resistance to perforation by both cal. .45 steel-jacketed ball projectiles and cal. .22 flak-simulating projectiles. Among the samples of any one alloy there was a slight tendency for the softer specimens to be somewhat more resistant.

5. However, the general level of resistance of even the best specimens was so considerably lower than that of Hadfield manganese steel of equivalent weight as to discourage the further consideration of steels of this type as prospective components.

---

3. Watertown Arsenal Laboratory Memorandum Report No. WAL 710/692, "Resistance of Monel Metal and Two High-Nickel Alloys of Various Hardnesses to Perforation by Flak-Simulating Projectiles", 11 September 1944.

J. F. Sullivan

J. F. SULLIVAN
Asst. Engineer

APPROVED:

E. L. Reed
for
N. A. Matthews
Major, Ordnance Dept.
Chief, Armor Section

TABLE I

Summary of Results of Tests on 18-8 Stainless Steel

Sample No.	Act. Gauge	Hardness (Rockwell "C")	% Nickel	Condition	Ballistic Limit (F/S) Cal. .45[1]	Ballistic Limit (F/S) G-2[2]
O-1	.042"	27	7.07	1/4 Hard	638	—
O-2	.042"	27	7.07	1/4 Hard	—	1055
O-4	.042"	27	7.07	1/4 Hard	616	—
O-5	.042"	27	7.07	1/4 Hard	—	1175
A-1	.042"	35	7.07	1/2 Hard	624	—
A-2	.042"	35	7.07	1/2 Hard	—	1052
B-1	.042"	42	7.07	Full Hard	656	—
B-2	.042"	42	7.07	Full Hard	—	1095
B-3	.042"	41	7.07	Full Hard	620	—
B-4	.041"	42	7.07	Full Hard	575	—
C-1	.041"	31	8.75	1/4 Hard	495	—
C-2	.042"	31	8.75	1/4 Hard	—	985
D-1	.042"	34	8.75	1/2 Hard	445	—
D-2	.042"	34	8.75	1/2 Hard	—	1033

TABLE I (CONT'D)

Sample No.	Act. Gauge	Hardness (Rockwell "C")	% Nickel	Condition	Ballistic Limit (F/S) Cal. .45[1]	G-2[2]
E-1	.041"	39	8.75	Full Hard	462	—
E-2	.042"	39	8.75	Full Hard	--	900
F-1	.042"	30	9.53	1/4 Hard	433	—
F-2	.042"	29	9.53	1/4 Hard	—	1038
G-1	.041"	34	9.53	1/2 Hard	390	—
G-2	.042"	34	9.53	1/2 Hard	—	975
H-1	.040"	37	9.53	Full Hard	377	—
H-2	.042"	36	9.53	Full Hard	—	915
For Comparison:						
Average Hadfield Manganese Steel	.042"	—	—	--	920	1630

[1]Cal. .45 steel-jacketed ball projectile - 230 grains.
[2]Cal. .22 flak-simulating projectile - 17 grains.

TABLE II

Chemical Composition and Physical Properties of Samples of 18-8 Stainless Steel as Reported by Republic Steel Corporation

Sample No.	Chemical Composition							Temper	Yield Strength	Tensile Strength	Elongation (2")
	C	Mn	P	S	Si	Ni	Cr				
0-1 to 0-5	.12	1.18	.023	.010	.44	7.07	17.90	1/4 Hard	101,620	140,320	29.5
A-1, A-2	.10	1.25	.035	.014	.45	7.07	18.14	1/2 Hard	117,970	164,440	17.5
B-1 to B-4	.10	1.25	.035	.014	.45	7.07	18.14	Full Hard	147,700	195,180	12.0
C-1, C-2	.08	1.12	.021	.015	.54	8.75	17.02	1/4 Hard	115,250	137,880	19.5
D-1, D-2	.08	1.12	.021	.015	.54	8.75	17.02	1/2 Hard	129,280	155,900	12.5
E-1, E-2	.08	1.12	.021	.015	.54	8.75	17.02	Full Hard	156,700	181,200	9.5
F-1, F-2	.11	1.07	.023	.010	.35	9.53	17.96	1/4 Hard	110,200	138,800	16.0
G-1, G-2	.11	1.07	.023	.010	.35	9.53	17.96	1/2 Hard	140,570	166,680	10.0
H-1, H-2	.11	1.07	.023	.010	.35	9.53	17.96	Full Hard	164,750	189,100	7.5

Comparative Resistance of Three Types of 18-8 Stainless Steel at Various Degrees of Hardness

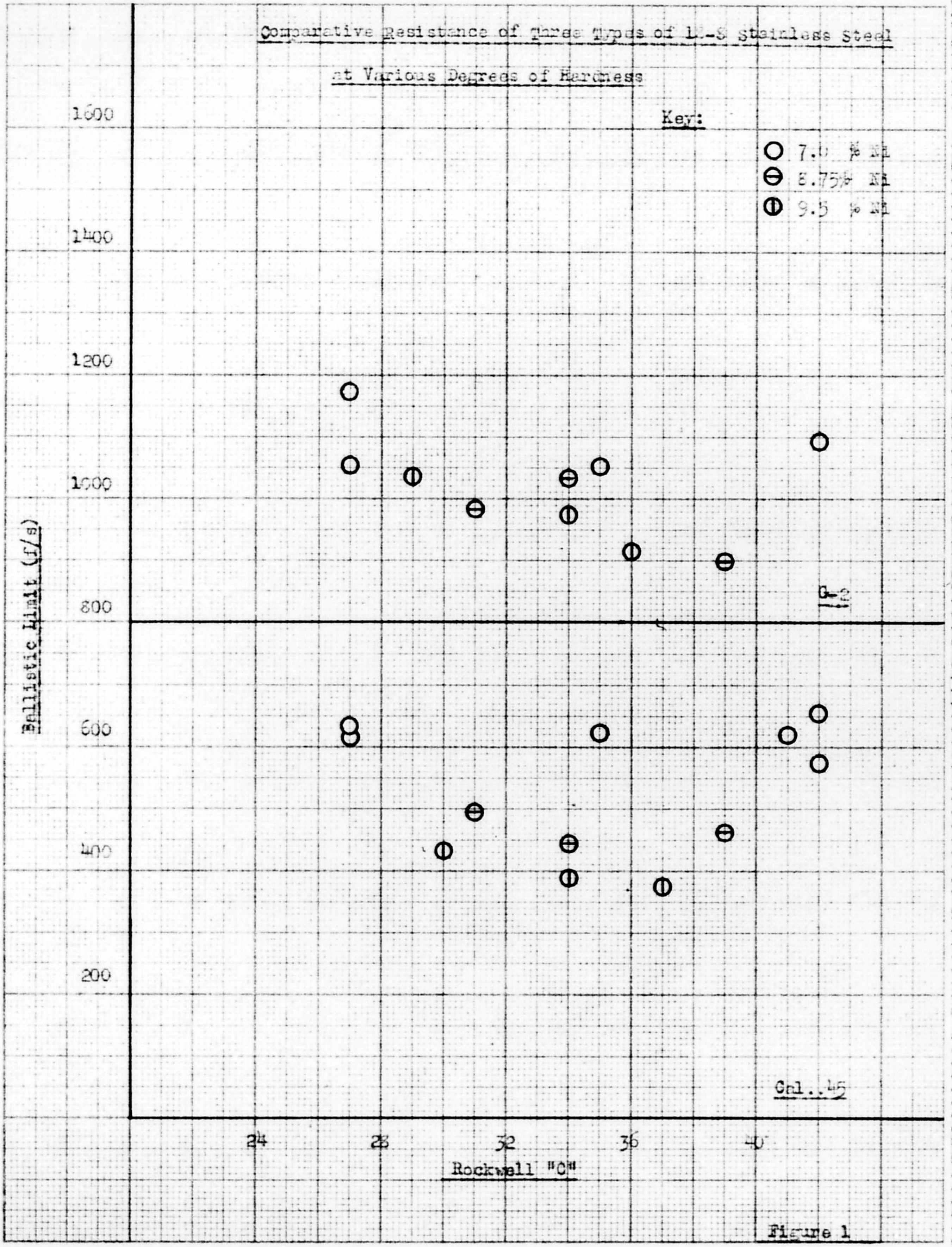

Figure 1

RESTRICTED

TITLE: Resistance of Variously Chemically Balanced 18-8 Stainless Steels in Various Conditions of Hardness to Perforation by Flak-Simulating Projectiles	ATI- 39247
AUTHOR(S): Sullivan, J. F.	DIVISION (None)
ORIGINATING AGENCY: Watertown Arsenal, Watertown Arsenal Lab., Watertown, Mass.	ORIG. AGENCY NO. WAL 710/693
PUBLISHED BY: (Same)	PUBLISHING AGENCY NO. (Same)

DATE	DOC. CLASS.	COUNTRY	LANGUAGE	PAGES	ILLUSTRATIONS
Sept' 44	Restr.	U.S.	Eng.	6	tables, graphs

ABSTRACT:

The resistance of chemically balanced 18-8 stainless steel in various conditions of hardness to perforation by flak-simulating projectiles was studied. Tests disclose a decrease in elongation and an increase in yield strength is accompanied by an increase in Ni content while the tensile strength remains essentially unchanged. The best combination of tensile strength and elongation is realized when the Ni content is lower. The materials best combining these two characteristics are most resistant to flak-simulating projectile perforation. Therefore, the 7% Ni alloy affords highest resistance to perforation by both, cal. .45 steel-jacketed ball projectiles and cal. .22 flak-simulating projectiles. Among the samples of any one alloy there was a slight tendency for the softer specimens to be somewhat more resistant. The general level of resistance of even the best specimens was considerably less than that of Hadfield manganese steel.

DISTRIBUTION: Copies of this report obtainable from Air Documents Division; Attn: MCIDXD

DIVISION: Ordnance and Armament (22) SECTION: Armor (5)	SUBJECT HEADINGS: Armor plate - Penetration (11503); Steel - Physical properties - (90397.8)
ATI SHEET NO.: R-22-5-23	